Urban Canopy Cover Pre-Assessment

ESPM 4041W: Problem Solving for Environmental Change

Report 8/8 Prepared for the City of Shoreview by:

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Executive Summary

The City of Shoreview is interested in better serving its residents by becoming a more sustainable community. One way it can do this is by assessing its urban tree canopy, an aspect of Shoreview which has many environmental applications. Canopy cover provides many benefits such as a moderated urban heat island effects, improved air and water quality, and vital habitat for wildlife. In order to reach these goals, city officials worked with University of Minnesota students in the Environmental Science, Policy and Management program to better understand the nature of Shoreview's existing canopy cover and to provide the necessary tools and information for taking the next step towards a sustainable urban tree canopy. This report was compiled in 2009 from September to December, and includes the following.

Objectives

- Estimate the amount and distribution of canopy cover and impervious surfaces throughout the city of Shoreview, MN.
- Identify areas of the city where canopy cover or pervious surfaces can be improved upon and make recommendations for future planning.
- Provide the city with the methodology for future urban tree canopy assessments.

Methods

The study area included the entire City of Shoreview, a fully developed second-ring suburb located ten miles northwest of St. Paul. The city was stratified into residential (including boulevards), commercial and park categories. A total of 100 randomly chosen sample sites were analyzed with high-resolution aerial photographs to assess existing canopy cover and impervious surface coverage. The sample sites were weighted by land coverage to include 60 residential, 20 commercial, and 20 park sites, of which ten percent in each category were ground truthed to ensure accuracy. Results were statistically analyzed using Microsoft Excel.

Findings

Average canopy cover for each category is as follows: Residential 51%, Commercial 11%, Parks 21%, Boulevards 30%. Canopy cover across the total area of Shoreview is 32%, which falls below the 40% recommended for cities east of the Mississippi. Residential canopy cover exceeds the recommended amount, while all other categories are deficient. The top four genera in the whole community make up 50% of the canopy: *Acer* (maple) 20.3%, *Picea* (spruce) 12.1%, *Fraxinus* (ash) 9.5%, and *Quercus* (oak) 8.2%.

Recommendations

1. Conduct a complete urban tree canopy cover assessment for the city of Shoreview.
2. Create canopy cover goals for residential, commercial, and city park areas.
3. Plant a variety of trees in sparse areas of the city.
4. Replace older pavement in low traffic areas with pervious pavement.
5. Increase vegetation in areas where trees are not suitable.

Introduction

Cities and forests are two different entities that are not usually in the same thought. Cities are envisioned as towering skyscrapers, sidewalks, buses, and the bustle of busy people. Forests evoke images of shady trees, meandering streams, and the calls of songbirds and other wildlife. It is often thought that these two things are mutually exclusive, and that the presence of one must preclude the other. However, urban areas can contain a surprisingly large amount of trees, parks, and other natural spaces. The incorporation of a forest within a city provides countless benefits to both urban dwellers and tree dwellers, and serves as proof that these two images are not so separate after all.

Urban tree canopy (UTC) is "the layer of leaves, branches and stems of trees that cover the ground when viewed from above" (USDA 2008). This urban tree canopy is comprised of trees in residential areas surrounding homes, trees in area parks or open spaces, and trees in commercial and business areas. UTC is important for many reasons, some of which are environmentally based: lowering heat in the city which saves energy consumption for cooling, improving stormwater quality, providing habitat and reducing pollution. Specifically, the trees act to intercept airborne pollutants, intercept rain during rain events reducing urban stormwater runoff problems, and also sequester carbon so there is less carbon dioxide in the atmosphere (Irani 2002).

Trees also serve to enhance the community: aesthetics for the residents in the city, creating educational and social opportunities, and enhancing property values (O'Neil-Dunne 2009). Along with residential and park areas, Canopy cover can be very beneficial to commercial and business areas in several different ways.

Trees can provide shade for people and cars, and therefore reducing urban heat island effects (Cappiella et al. 2006). It has also been suggested that trees have an aesthetic value that influences peoples' behavior and contributes to a positive shopping experience (Wolf 1998).

UTC assessments are becoming more and more popular to estimate the amount of canopy cover benefits in an area. For example, the cities of Minneapolis and Woodbury are letting out contracts to conduct assessments this fall, while St. Paul is still working on funding for their own. From these assessments the city gains insight on the amount and location of UTC, specifically, areas that are at UTC capacity and areas that potentially could increase their UTC. The city can also use these assessments to provide background information for grants or future policies relating to UTC.

"Researchers estimate that tree canopy cover in urban and metropolitan areas across the U.S. averages only 27% and 33% respectively" (Dwyer and Nowak 2000). It is

important to set UTC goals in order to maintain or increase UTC, primarily because there are external stressors, such as pests or diseases, which can affect the life spans of trees present, (CWP 2008). Having these goals set will allow for specific management tactics to be used to protect the UTC. Management to increase or maintain a current level of UTC is critical for urbanized areas today because of these many reasons, including: environmental issues such as decreasing storm water runoff and urban pollution, and others like providing benefits to the city such as beautiful trees and shade. Setting goals and managing for the UTC now is more beneficial than reacting to unpredicted losses in the future.

Course Vision Statement

We envision a sustainable Shoreview: a city that balances social equity, economic vitality, and environmental integrity in order to maintain and improve the quality of life for current and future residents. We aim to further enable Shoreview by:

- Providing relevant tools and information.
- Encourage an active and aware citizenry.
- Addressing perceived barriers to action.
- Fostering responsible and collaborative resource management.

Our project strives to empower sustainable behavior and policy changes that will establish Shoreview as a model for other communities.

Report Vision Statement

The goal of this report is to provide the city of Shoreview and its residents the tools and information needed to better understand their urban forest resources. The urban tree canopy pre-assessment will offer an examination of the existing and potential forest cover, while the recommendations given will explain how Shoreview can effectively manage their land and forest resources to become a pioneer in urban forest management.

Objectives

- Estimate the amount and distribution of canopy cover and impervious surfaces throughout the city of Shoreview, MN.
- Identify areas of the city where canopy cover or pervious surfaces can be improved upon and make recommendations for future planning.
- Provide the city with the methodology for future urban tree canopy assessments.

Methods

Study Area

Shoreview, Minnesota, is a second-ring suburb in Ramsey County. It is located approximately ten miles northwest of St. Paul and encompasses slightly over twelve square miles (Shoreview 2009). Shoreview is a fully developed community primarily residential in nature, with several commercial and industrial areas in the southern portion of the city. There are numerous city parks with a variety of trails, playgrounds and athletic facilities, as well as multiple open spaces and wetlands, and 11 lakes.

The City of Shoreview was incorporated in 1957 (Shoreview 2009). The majority of its residents are married and living in households (City-Data.com 2009). The median age is approximately 39, which is slightly older than the state median of 35. Shoreview is also relatively affluent when compared to Minnesota as a whole, with a median income of almost $79,000.

The assessment of canopy cover was conducted within the city limits. Open spaces were disregarded because they fall under Ramsey County jurisdiction, as were boulevard trees on major county or federal roads such as County Road 96 and Highway 694. The focus of the analysis was on three different types of land use categories: residential (including boulevard trees), commercial, and parks.

Selecting Sites

The city of Shoreview was stratified into three general areas: residential, commercial and parks. This stratification procedure was modeled after the USDA Forest Service's Urban Forest Effects Model (UFORE). Different strata, or land classes, were chosen because each area in Shoreview has different levels of forest and should have different canopy goals. One hundred sites were sampled that were proportionally weighted by their land coverage of Shoreview. The zoning map of Shoreview was particularly useful for designating the stratum extents (Figure 2). The resulting groups (bins) for residential, commercial and parks were 60, 20, and 20 respectively.

A transparent dot grid was overlaid on the zoning map to choose the sample sites in each stratum. To ensure unity every seventh dot in each stratum was picked to sample in each bin allocation. In addition to the 100 sites detailed above, 50 boulevard sites were chosen in the residential sector. For each residential site that was located on a city street, a boulevard site was established on the south or west edge of the road.

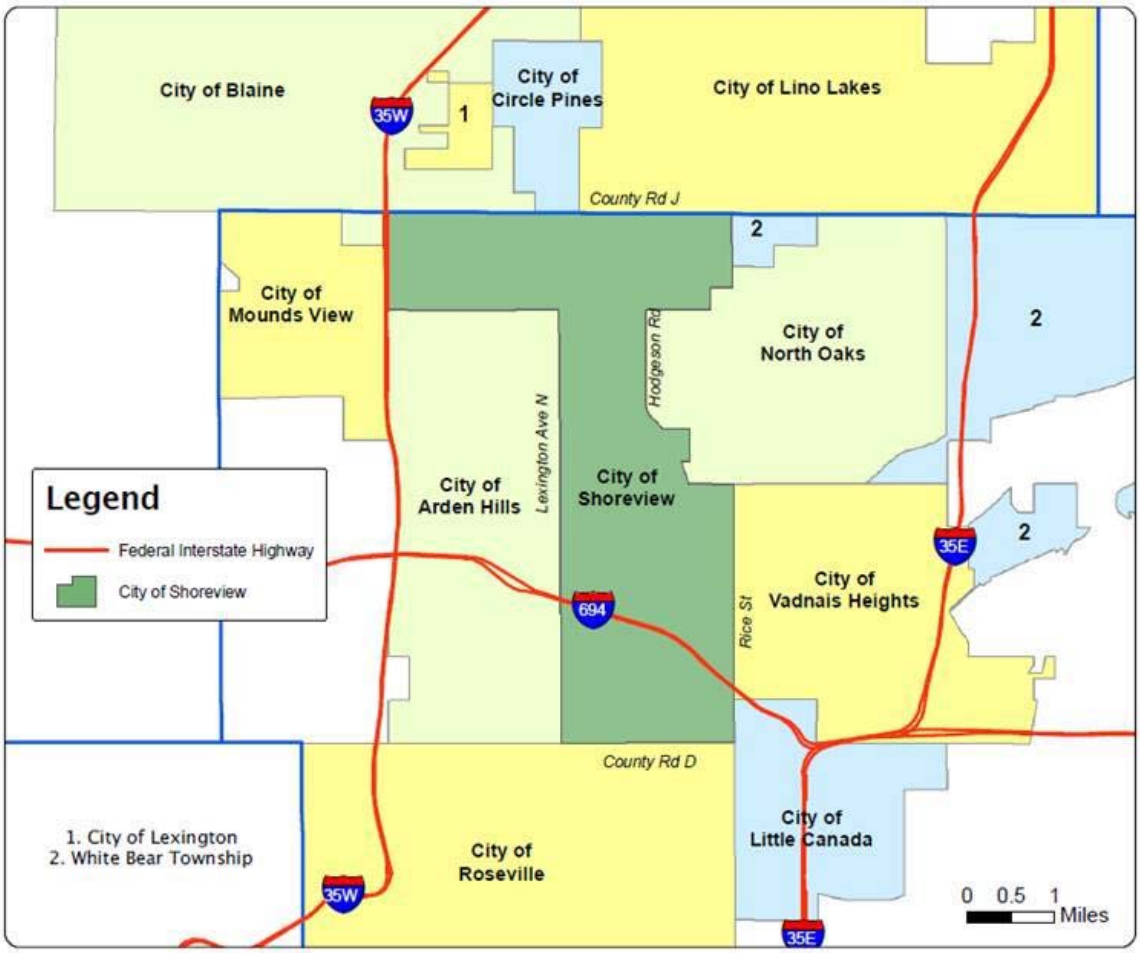

Figure 1: Detailed map of Shoreview, including neighboring communities and major transporation routes. County boundaries are shown in blue (Shoreview 2009).

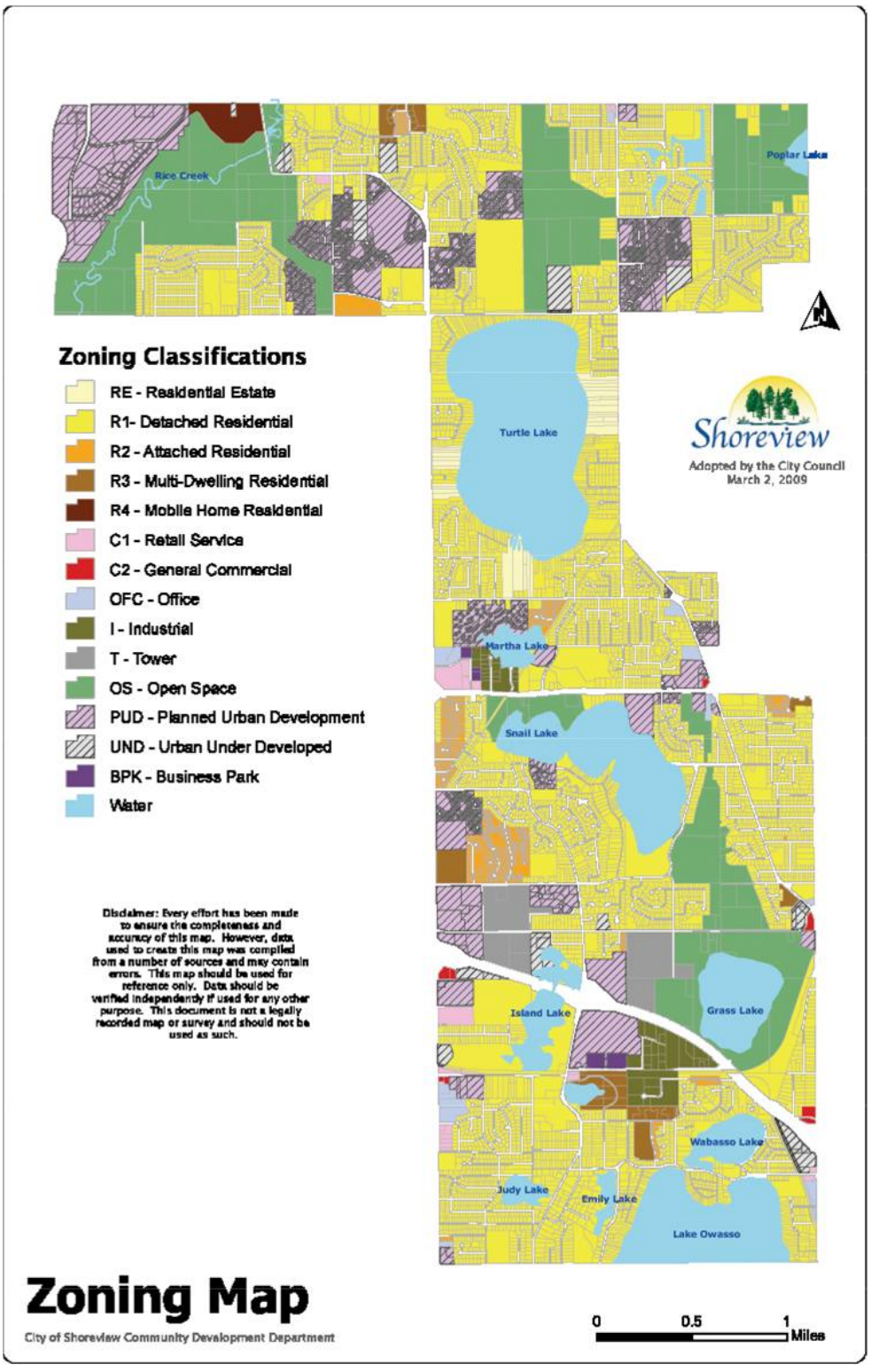

Figure 2: City of Shoreview's zoning areas (Shoreview 2009).

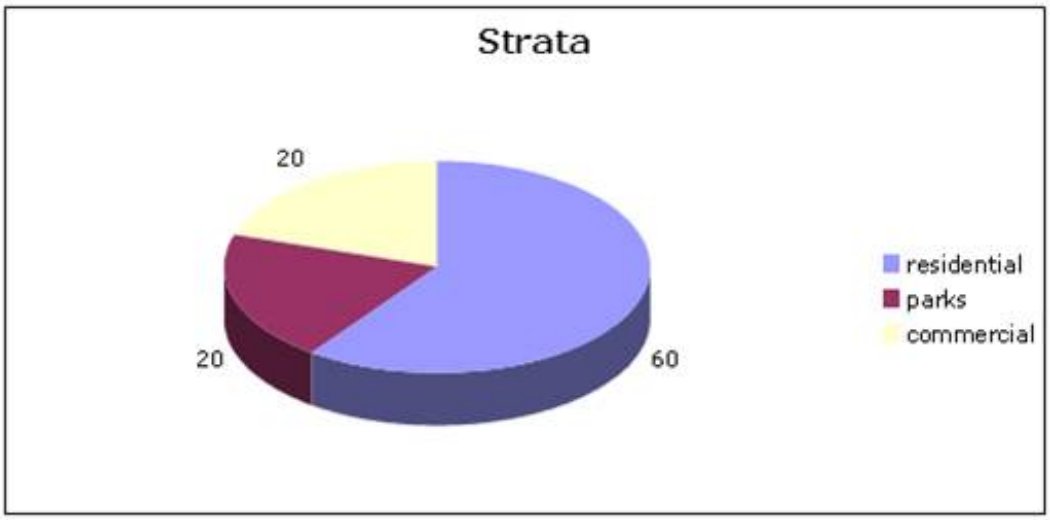

Figure 3: Breakdown of bin size.

Assessing Sites

Once the sample sites were chosen, high-resolution aerial photos from Google Maps were used to conduct visual assessments of canopy cover and impervious surface coverage (Google Earth). The photos had a minimum mapping unit of one meter, which allowed for the 100 zoning-based sample sites to have an area of approximately one half-acre. The 50 boulevard sites were analyzed a little differently due to the narrow nature of the easement boundaries. Each site was approximately 100 feet in length and 20 feet in breadth, centering on the south or west edge of the road.

Two different photos were used for the canopy and impervious surface assessment. A photo taken during the spring when foliage was more abundant was used to assess total canopy cover (http://www.lmic.state.mn.us/). Conversely, a photo from Google Earth taken during the fall was used to assess impervious coverage. This photo showed improved clarity of impervious surface under the canopy. The location as well as percent coverage of canopy and impervious surface was recorded for each site. Assessing the percentage of trees was very straightforward: the amount of foliage coverage from canopy was simply estimated for each half-acre plot. Likewise, any impervious surfaces such as streets, sidewalks, and houses were estimated for the impervious assessment.

Ground Truthing

A random number generator (Haahr 2009) was used to select sites from the location list generated earlier. Ten percent of the bin sizes for each stratum were then ground truthed. The resulting sizes were 6 for residential, 5 for boulevard, 2 for commercial and 2 for park sites.

For each ground-truthed site, the percentage of canopy cover and impervious surface coverage was estimated within a half-acre area. Within this circle the relative percentage of coverage was observed. At each residential site a boulevard assessment was also conducted on impervious surface and canopy cover. A 100-foot transect line was measured along the edge of the street and assessed tree cover and impervious surface percentages within ten feet on either side of that line. This data allowed the assessment for accuracy of the visual assessment using high-resolution aerial photos.

Interpreting Results

Microsoft Excel was used for a basic statistical analysis of the data. Averages and standard deviations were calculated to help determine estimates for the percentage of tree cover and impervious surfaces in Shoreview. Previous canopy assessments and UFORE data from cities nationwide were reviewed, summarized, and compared to Shoreview's data in order to better evaluate Shoreview's current canopy condition. The full UFORE report for Minneapolis, MN includes this nationwide data and is included in Appendix A.

Collaboration

Another important aspect was the collaboration with the UFORE within the class project in order to gain a better perspective on the composition of Shoreview's canopy cover. The Urban Forest Assessment (2009) report focuses on data about the species composition in the city. The inventory information and analysis was used to lend a more accurate perspective to the canopy assessment, specifically in regards to the percentage of ash trees with the concerns of the Emerald Ash Borer. The information provided on species diversity added a species vulnerability perspective to the canopy cover element.

Findings

The data from this pre-assessment of Shoreview's urban canopy show canopy levels near the recommendation levels for cities east of the Mississippi River (American Forests 2009). In the instance of residential canopy cover, Shoreview has levels over what is recommended, while in the commercial sector, Shoreview is below the recommended level. When total area is looked at, Shoreview is falls below the recommended 40% canopy cover.

These numbers can be split in two groups: public lands which include parks and residential boulevard right of ways, and private lands with are comprised of residential and commercial plots. The average tree cover on public lands in Shoreview is 27%, while the average tree cover on private lands is 36%.

Table 1: Recommended and actual average canopy and impervious surface cover in the City of Shoreview.

Land type	Area of land type	Recommended % tree cover	Actual % tree cover	% impervious
Residential	3,509 acres	50	51	35
Commercial	210 acres	15	11	69
Parks	219 acres	20	21	21
Residential/Boulevard	100 acres	N/A	30	63
Total area	**7,067 acres**	**40**	**32**	**47**

When compared to other cities in North America, Shoreview rates well; only Atlanta, Georgia, has an average UTC greater than Shoreview's 32%, and Minneapolis, Minnesota, rates third with an average UTC of 26% (UFORE 11/09). In addition to providing general canopy cover averages, the UFORE reports also include information on watershed impact, pollution removal rates, and status of the urban forest. These tools aid in the creation of a forest management plan. A link to a full UFORE report for Minneapolis, MN, can be found in Appendix A.

The USDA Forest Service has done a national canopy assessment using National Land Cover Data, low-resolution satellite imagery (30 m). This NLCD standardized assessment ranked communities on the scale of excellent, very good, good, fair, to poor when compared with their neighboring communities of comparable size. Shoreview ranked fair, meaning that 50-70% of its companion communities had more tree cover than Shoreview.

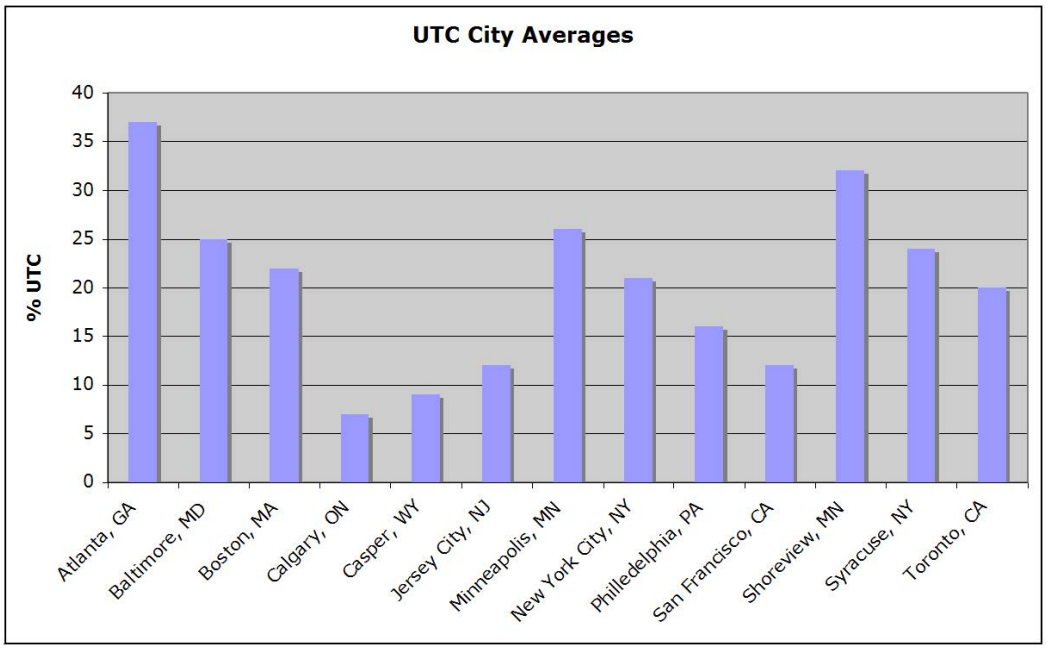

Figure 4: Shoreview's average UTC compared to average UTC cover in some North American cities (UFORE 2009).

In addition to an urban canopy pre-assessment, a forest inventory was completed for the city of Shoreview. Thirteen genera account for 91% of the city's tree canopy. The top four genera in the whole community make up 50% of the canopy: *Acer* (maple) 20.3%, *Picea* (spruce) 12.1%, *Fraxinus* (ash) 9.5%, and *Quercus* (oak) 8.2% (Urban Forest Assessment 2009) (Figure 5).

The canopy diversity within the residential stratum closely reflects the city's overall canopy diversity; the largest genus group seen in the residential strata is *Acer* (maple) accounting for 19.9% of the canopy density, followed by *Picea* (spruce) with 12.6%, *Fraxinus* (ash) 9.1%, and *Quercus* (8.4%). Together these four genera make up 50% of the residential canopy. The commercial stratum has the least diverse canopy with the top four genera making up 78.8% of the canopy: *Populus* (cottonwood, poplar) 34.6%, *Acer* 19.2%, *Fraxinus* 15.4%, and *Salix* (willow) 9.6% (Urban Forest Assessment 2009) (Figure 6).

The public areas have similar canopy densities to the commercial stratum with the top four genera making up between 70% and 80% of the total canopy. The top four genera in the park stratum make up 77.5% of the total park canopy. The genera are: *Pinus* (pine) 26.5%, Populus 24.5%, *Fraxinus* 16.3%, and *Acer* 10.2% (Figure 6). The top four boulevard trees make up 71.4% of the total boulevard stratum, however, the dominant genus in this stratum is *Acer* making up 39.3% followed by *Fraxinus* 11.9%, *Quercus* 10.7%, and *Picea* 9.5% (Urban Forest Assessment 2009) (Figure 6).

The most at-risk areas in Shoreview with respect to disease or pest are the areas with large percentages of one genus. City parks are at risk because two genera make up 51% of park canopy: *Pinus* comprises more than one-fourth of the park canopy and *Populus* makes up nearly another one-fourth of the canopy density. Likewise, boulevard right of way areas are at risk because more than a third of the boulevard trees are in the *Acer* genus.

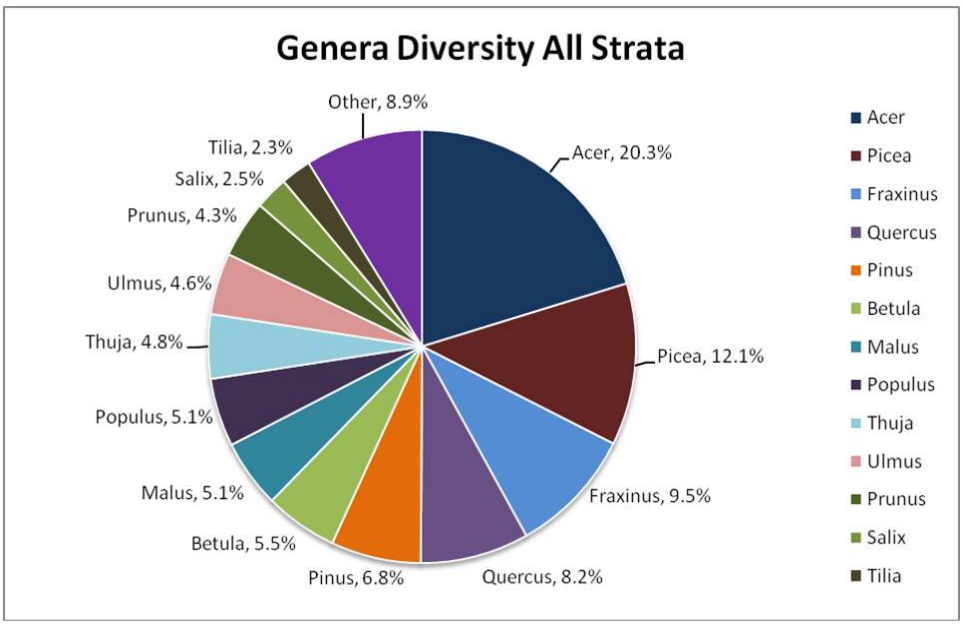

Figure 5: Genera diversity within the Shoreview community (Urban Forest Assessment 2009).

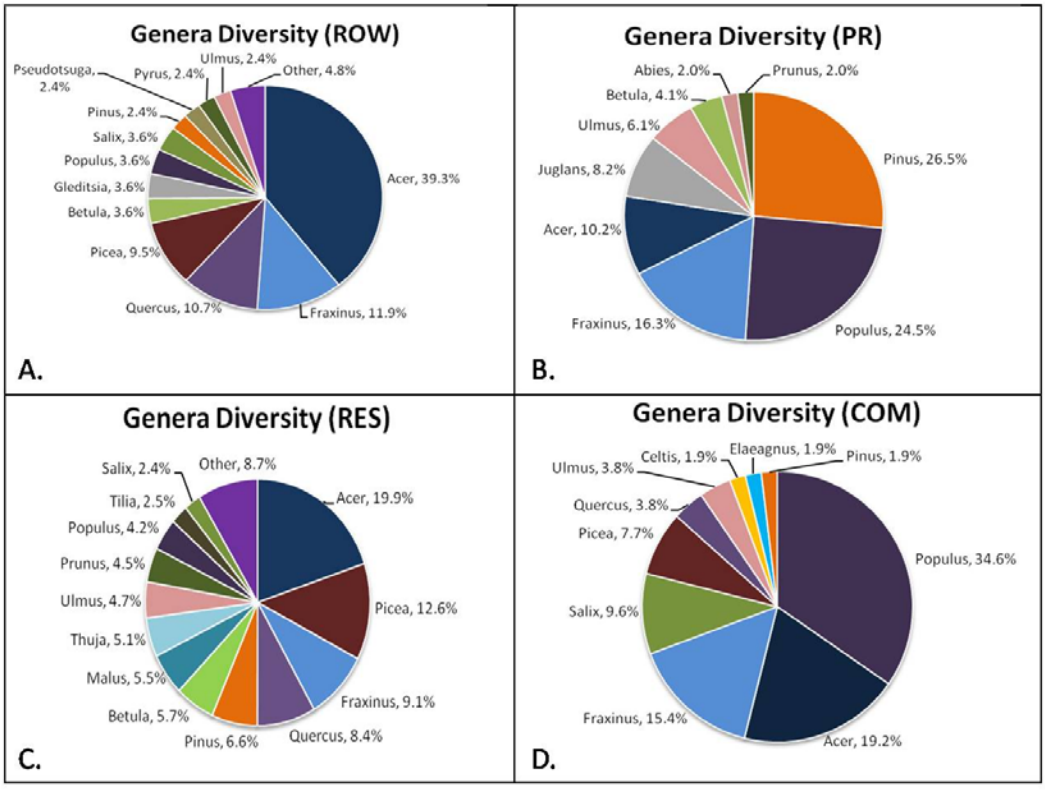

Figure 6: Genera diversity within each stratum: (a) boulevard right-of-way, (b) city parks, (c) residential plots, (d) commercial plots (Urban Forest Assessment 2009).

Recommendations

1. Conduct a complete Urban Tree Canopy Assessment for the city of Shoreview
2. Create canopy cover goals for residential, commercial and city park areas along with a management plan for existing canopy cover
3. Plant a variety of trees in sparse areas of the city
4. Replace older pavement in low traffic areas with pervious pavement
5. Increase vegetation in areas where trees are not suitable

Discussion of Recommendations

No Action Scenario

The urban forest resource is a dynamic environment; over the years there will be natural gains and losses to this resource. Old age, invasive pest, and disease can all harbor declines in the urban tree canopy. Planning is necessary to replace lost trees or canopy cover will be threatened. With the onset of invasive pests, such as the well-known Emerald Ash Borer, there is a greater need for species diversity within the tree community. An invasive pest or disease has the potential to completely deplete an area of an entire species in a dramatically short period. This would result in host of damaging consequences to various aspects within the urban forest. Residents primarily face declining property values, while safety, liability, water quality, and erosion control are risks the city may face if no actions are taken proactively to plan for canopy loss.

Different areas of Shoreview have varying degrees of susceptibility to canopy loss due to disease or pest. Currently the emerald ash borer threatens the *Fraxinus* population, for the community of Shoreview this means that 9.5% of the total canopy is at risk (Urban Forest Assessment 2009). When viewed through the strata parks could lose up to 16.3% canopy, commercial areas could experience 15.4% canopy loss, boulevard right of ways could lose 11.9% canopy, and the residential areas have 9.1% canopy at risk. Because the residential stratum is so large 9.1% equals nearly 225 trees, while the 16.3% of at-risk ash trees in the city parks equals about 8 trees. While the emerald ash borer is the most eminent threat to Shoreview's urban canopy, genera other than *Fraxinus* should be examined. *Acer* is the dominant genus in Shoreview, and if maple wilt or the Asian long-horned beetle were to emerge as a serious threat, 20.3% of Shoreview's canopy would be at risk.

The aesthetic values that trees provide are a positive influence for residential property values. Trees add thousands of dollars to the value of a home (Stromme 2000). If no actions are taken to conserve and promote Shoreview's urban canopy, surely trees will be lost. This would have devastating effects for property values. The residents of Shoreview would suffer tremendously from this loss since much of each resident's worth is coupled to their property.

According to Shoreview's own *Declaration of Policy and Intent* within the Municipal Code, "It is the intention of the city council to control and prevent the spread of diseases and other epidemic diseases of shade trees." Therefore, the city should take proactive steps to remove diseased trees before they cause costly damage. The responsibly and, hence, risk of trees located on private property that impede onto public lands lie on the shoulders of the resident and the city. If a defect or hazard in a tree is not obvious to the resident before the tree falls, then the responsibility lies on the city to take care of the damages if said tree can cause damage within the right of way areas. If there is negligence by city officials to identify hazardous trees, the city is liable for the damages caused by fallen trees (Stromme 2000). The municipality can limit its risk by monitoring and providing general maintenance for at risk trees.

Concerning the issue of water quality, the city could face fines if they do not meet requirements for water quality. The Minnesota Pollution Control Agency (MPCA) holds the authority to write and enforce water quality rules and regulations. According to the MPCA, they can fine offending municipalities for pollutants in stormwater above allowed levels as well as point and nonpoint source pollutants (MPCA, Enforcement Actions). The amount of canopy cover and impervious surfaces within a city directly relate to the health of the watershed and are incredibly important to water quality. If the number of trees were to decrease, for any reason, runoff would increase. Added inputs into the storm water system would only increase the stress on area lakes and streams which are already struggling to accommodate human influence.

The City of Shoreview already contains a vast and impressive urban forest resource. However, the services that this resource provides is not a given. Internal and external forces help shape the health of the canopy. Without future plans to further diversify and expand this resource, Shoreview will continue to be at risk. Any loss of the tree canopy will have immediate effects on property values, water quality integrity, and the general security of the city itself and its residents. We feel that investments now would only reap unbound benefits for generations to come. Financial, time, and manpower constraints should be weighed against the many advantages Shoreview's forest resources offer. We urge Shoreview to invest in preventative measures now to combat against the unclear and unwritten future. Our argument is best be summed up by a few simple words from a world-renowned scientist and politician.

"An ounce of prevention is worth a pound of cure" Benjamin Franklin.

Conducting an UTC Assessment

Other metropolitan cities, including Minneapolis and Woodbury, have already begun their UTC assessment processes, some in response to pressures from government agencies and others as a means of developing baseline estimates of canopy cover in their cities. Conducting an UTC assessment is a proactive way of approaching the many uncertainties of the future, including weather, pests and diseases that could diminish the canopy cover in Shoreview.

Create Canopy Cover Goals

As stated previously in the report, creating canopy cover goals is an important step to ensuring the safety and endurance of Shoreview's canopy cover. Having specific canopy cover goals and a maintenance strategy give the city a plan and numbers to work towards as well as showing how proactive Shoreview is concerning canopy cover. American Forests suggests that suburban areas should have goals of 50% canopy cover. Shoreview is close to that goal, but should consider increasing their UTC to 50% in residential areas. This number is a standard used by American Forests for "suburban residential zones east of the Mississippi River and in the Pacific Northwest" (American Forests 2009). For commercial areas Shoreview should create a goal of 15%, a common recommendation from various assessments including Chesapeake Bay and Vancouver. City parks are not normally quantified in the recommendations with a specific goal; however with so much space available for increasing canopy cover in Shoreview, it is an important area for improvement. One tree canopy assessment suggested a 25% goal for their developed parks (Seattle). This number seems too high because most of the city parks in Shoreview are "field-sport based," so they cannot increase to that high of a goal. A canopy cover goal of 20% is reasonable for the park areas.

Along with creating these goals, the city should outline a plan to reach and maintain these numbers. A 10-year plan to reach these initial goals is the general standard used in other reports such as with Chesapeake Bay and Vancouver. This plan should include a city tree inventory, a plan to replace dead or dying trees, and a plan of replacing trees in general over time. Replacing older trees with newer, more diverse species will help the urban forest of Shoreview.

Planting Trees in Sparse Areas

Planting trees in sparse areas of Shoreview would be an ideal way to increase the average urban tree canopy. Specific areas in residential spaces include the most recent developments where the trees are younger, areas that have been affected by storm/wind damage where replacement was not a feasible option, and multifamily housing where the land is not controlled by the homeowner. Other sparse areas include commercial and business land where there is a lot of pavement, and finally in city parks where there is a lot of open space available for tree planting. Species diversity is an important aspect of urban forests by acting as insurance to the tree community. If a pest or disease destroys one particular species of an area, the overall loss is not as great if there are plenty of other species remaining.

1. Residential. In the residential areas of the city, the Shoreview can plant boulevard trees in areas that are suitable. Following the example of Minneapolis, sidewalks can better accommodate trees by installing rings or arcs around trees to protect the root zone. Removable sidewalks are also effective because they allow the slabs of pavement to be easily removed if damaged by growing roots (City of Minneapolis). Concerning private land, Shoreview could encourage the planting and replacement of residential trees. Bloomington had a good idea to hold public tree sales and provide

educational packets on proper tree care. These tree sales could offer species of trees that are not common within the community, thus decreasing the overall vulnerability of Shoreview's urban tree canopy. These recommendations are feasible ways the city can accommodate trees in commercial areas that have been used in nearby cities.

2. Commercial. There are a lot of opportunities for improvement in canopy cover when it comes to the commercial and business areas of Shoreview. These improvements can be made either on the perimeter of parking lots and buildings or in constructed islands within the parking lots. Canopy cover of these areas depends on both the number of trees present and the size to which those trees are able to grow.

Whether it is the perimeter or the middle, parking lots are harsh environments for trees due to warmer temperatures and drought conditions, lower soil nutrients, soil compaction, and frequent salting and plowing in the winter (Cappiella et al. 2006). Therefore, careful consideration must be given when selecting tree species in order to find those species which are tolerant to these stressful conditions. Other useful characteristics to look for include a wide spreading canopy to maximize the area covered, trees that do not produce much leaf litter, fruit, or nuts, and a diversity of different species to avoid a monoculture (Cappiella et al. 2006). Appendix B includes a list of trees that are suitable for parking lots and other paved areas, as well as a list of trees that should be avoided for these areas.

Once suitable trees have been selected, there are several ways to ensure that they become healthy and successful. One way to do this is to minimize soil compaction near their roots. The City of Minneapolis Urban Forestry Policy includes the concept of a protected root zone (PRZ) around each tree where equipment cannot be placed and pedestrian and vehicular traffic is prohibited (City of Minneapolis). A PRZ can be used to protect existing trees during construction or renovation projects, and to allow newly planted trees to become well-established. The idea of using PRZ protection for commercial areas would be to avoid damage to roots in those areas. This could be done by protecting the soil with a pervious pavement that minimized compaction yet allowed moisture and oxygen penetration. It could also be interpreted as the area where more suitable soil for growing trees would be provided. The whole parking lot does not have to have beautiful soil under it, only in the areas defined as PRZ. Soil compaction can also be prevented in islands and strips by planting shrubbery in between trees to discourage people from walking over them (Gilman). Using structural soil, a mixture of soil and aggregate material, is also beneficial because the aggregate material is better able to support the weight of pavement, pedestrians, and vehicles, while the soil remains well-aerated for roots to grow through (Gilman). This “soil” could be the growing medium under the pavement for the desired PRZ measurements.

Trees planted in buffer strips at the perimeter of parking lots usually fare better than those planted in islands because they tend to have more adequate growing space for their roots (Gilman). However, if these buffer strips are also located under utility

Figure 7: Roots cracking a curb in a narrow island (Gilman).

Figure 8: Big islands provide adequate root space for healthier trees. The two trees indicated by blue arrows are larger and darker green than the tree on the right.

wires or streetlights, they will have to be frequently pruned, which will prevent them from growing a canopy large enough to noticeably improve urban canopy cover (Gilman). Buffer strips should also be wide enough to support the large root systems of trees. If a buffer strip is too narrow, the roots will have to find suitable soil underneath the pavement, which may cause infrastructure damage later when the roots get bigger (Gilman).

Islands and linear strips are a good way to increase the canopy cover inside parking lots. However, just like with buffer strips, islands and strips must be large enough to accommodate large trees and their roots in order to provide a significant amount of canopy cover (Gilman). If trees are planted too closely to a curb, they will likely crack the pavement as they mature (see Figure 5). While installing root barriers may minimize such infrastructure damage, planning ahead and providing trees with enough soil space from the beginning will accomplish the same goal more simply.

3. Parks. Increasing canopy cover in city parks will provide many benefits to Shoreview including: increasing species diversity to eliminate effects from pests/disease that may reduce one single species, aesthetic benefits to park visitors, wildlife habitat, and buffering pollutants and contaminates from entering lakes and city water. Parks contain vast areas of open space where trees could be planted to help with sequestering carbon and reducing Shoreview's carbon footprint. Trees can be planted on the borders of parking lots, or near and surrounding smaller ponds in the areas acting as a buffer. They can also be planted between fields; this would add more shade to the spectators who love to watch their children play sports.

Pervious Pavement

Pervious pavement is another option to consider. According to the National Ready Mixed Concrete Association, “by capturing stormwater and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing stormwater runoff, and meeting U.S. Environmental Protection Agency (EPA) stormwater regulations” (NRMCA). Porous concrete is one of the recommendations the EPA uses for its Best Management Practices for reducing the quantity of stormwater runoff. Pervious pavement is another tool for new development and redevelopment such as repaving older roads and parking lots. In addition to reducing the pressure of stormwater runoff, pervious pavement creates a better growing environment for tree roots by allowing rainwater and oxygen to diffuse into the soil where the roots are growing. Healthier root systems equal healthier and larger trees.

Many types of pervious pavement available, including poured-in place pervious asphalt, which is dark in color like regular asphalt, however, its small stone and fine particulate matter are removed and the quantity of tar reduced. There is also poured-in place pervious concrete surfaces, which are lighter in color and made with larger pea gravel. This pavement has a pebbly surface that is flattened with a roller. Another option is the block and concrete modular pavers which allow water to pass through the blocks of concrete into a layer of sand and gravel. This layer allows water to filter

through slowly, which provides 20-50% more water infiltration compared to regular impervious pavement (Lake Superior). Finally, turf pavers are used for the reduction of impervious surfaces. They consist of a "grid pattern that is usually honeycombed or lattice shaped and the voids collecting water during rain events, which then slowly drains into the soil below" (Twin Cities).

Figure 9: Turf paver in a small parking lot (Twin Cities).

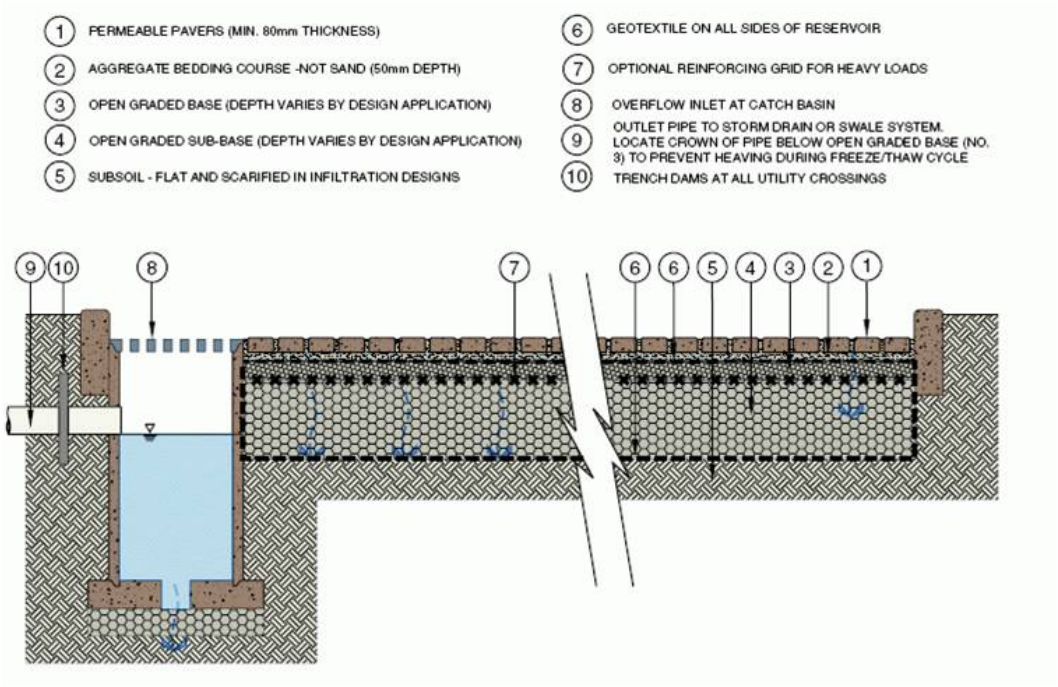

Figure 10: Pervious pavement diagram (Lake Superior).

Prior to construction, there are many tests to ensure the area is fit for pervious surfaces. These should be low traffic areas and the soil infiltration rates should be tested with the minimum of 0.27 inches infiltrating into the soil within one hour. The base below the pervious surface should be composed of "clean, washed stone with 25-35% voids" (Lake Superior), to ensure proper infiltration. For a successful pervious system, the area should be completely drained within 12 hours following a rain event.

During the construction process, use of machinery should strive to limit soil compaction. Also, stormwater should be diverted from the area to keep the base materials below the pervious surface clean and free of sediment which could clog the infiltration pores. The layers needed, from top to bottom, include:

- Pavement –three-quarters (asphalt) to four inches thick (pavers)
- Filter Course–two inches thick made of half-inch crushed stone
- Reservoir Course–thickness based on runoff storage required and frost penetration, made with one and a half to three inch diameter stone
- Filter fabric
- Existing soil managed to have minimal compaction to retain soil porosity

Compared to regular concrete, the costs of these pervious surfaces are a bit higher: 10-15% higher for porous asphalt, and about 25% greater for pervious concrete. At up to four times the cost of regular pavement and concrete, the turf pavers are most costly and so are generally used in smaller areas like driveways. Maintenance of these areas is typically $200 per acre per year (Lake Superior), as vacuuming and power washing is required. However, higher installation and maintenance costs can be off-set by the elimination of the need for curbs, gutters, storm drains and large retention ponds for filtering stormwater runoff. Also, many communities will reduce their stormwater fees in recognition of these new pervious surfaces.

Limitations of pervious surfaces include the cost of construction and maintenance, selecting the right areas for successful implementation, incorrect installation which leads to an unsuccessful pervious surface system, and the risk of contaminating nearby waters.

City park parking lots in Shoreview are a great candidate for the implementation of pervious pavements. These parking lots contribute to most of the impermeable surfaces within Shoreview's city parks. Also, they are not high traffic areas, so they will hold up well compared to other higher traffic parking lots or main roads. Another option is to create more neighborhoods like the Woodbridge Neighborhood off of Rice Street. This low traffic residential area is great for pervious pavement and it decreases storm water runoff, while also recharges the moisture content within the soil which is beneficial for trees (Gilman).

Figure 11: Photo of pervious pavement on Woodbridge Street.

Finally, in areas where planting trees and pervious pavement are not feasible, the city of Shoreview should increase other vegetation. This slows down rainwater and increases infiltration into the soil compared to impervious surfaces and bare soil. Grasses, bushes and shrubs provide habitat for smaller animals and are more visually appealing than bare soil.

These recommendations, if followed, will allow the city of Shoreview to save money on cooling costs in the summer, avoid water quality fines, increase the value of their residential properties, lower their carbon footprint, and become a leader in managing their UTC.

Conclusions

The city of Shoreview has a substantial urban forest resource. This preliminary assessment's goal was to quantify the extent of this invaluable resource. Our methods, which utilized important protocols from the United States Forest Survey, allowed us to estimate the approximate canopy and impervious surface extent over Shoreview's landscape. Our assessment found that residential areas had a mean percentage of 51% and 35% for canopy and Impervious surface respectively.

Commercial areas came in at 11% and 69%, while parks were at 21% and 21% overall. The existing residential urban canopy is strong overall when compared to other cities around the state and nation. However, commercial areas are substantially lagging behind especially for impervious surface extent.

Shoreview already contains a strong urban forest; however, this forest is a dynamic attribute. It is in the city's best interest to draw plans to continue to proactively manage and pre-empt any threats to this resource. Careful consideration to species diversity and proper management of the existing canopy will ensure generations of practical benefits from the urban forests of Shoreview. Proper placement and installation of pervious pavement technologies can also greatly reduce Shoreview's environmental impacts. Shoreview is poised to become a leader in the Twin Cities metropolitan area for best management practices of the urban tree resource and implementation of pervious pavement technologies.

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Appendix A: Resources

UFORE Resources

http://www.ufore.org/

This website provides links to UFORE reports of the following cities: Atlanta, GA; Baltimore, MD; Boston, MA; Calgary, AB; Jersey City, NJ; New York, NY; Philadelphia, PA; Syracuse, NY; and Toronto, ON. It also provides an in depth review of the UFORE model, history, and process.

http://nrs.fs.fed.us/data/urban/

This website provides links to the UFORE reports of the following areas: Casper, WY; Minneapolis, MN; New Castle County Metro Corridor, DE; New York, NY; Philadelphia, PA; San Francisco, CA, Wilmington, DE; and Washington, DC. National Land Cover Data (NLCD) is also available fore each state as downloadable GIS files.

Pervious Pavement Resources

http://www.flowstobay.org/ms_sustainable_guidebook.php.

Sustainable Streets Guidebook – This resource provides information about low impact development technologies, with a focus on pervious pavement and stormwater management.

Appendix B: Suitable and Unsuitable Trees for Paved Areas

Parking lots and other paved areas are stressful environments for growing trees. Pavement acts like a heat sink for solar radiation, as well as for heat reradiated from buildings and cars. The impervious nature of pavement also directs runoff into storm drains, thereby depriving the underlying soil of moisture. Soils also tend to be low in nutrients and have undergone significant compaction. Here in Minnesota, the added stressors of road salts and snow plows in the winter are also detrimental for trees. All of these factors contribute to trees that are poor in quality and have short life expectancies. With proper planning and consideration, however, much of these stressful factors can be reduced. It is possible to create a healthy and attractive urban canopy for parking lots by selecting appropriate types of trees. The following lists contain trees that are suitable for paved areas, as well as trees that should be avoided. As with other aspects of urban forest canopy, species diversity is important. For more information about tree selection for paved areas: http://pubs.ext.vt.edu/430/430-028/430-028.html

Trees for Parking Lots and Paved Areas

Common Name	Latin Name	Cultivars and Comments
Hedge maple	*Acer campestre*	
Amur maple	*Acer ginnala*	
European hornbeam	*Carpinus betulus*	'Fastigiata'
Katsuratree	*Cercidiphyllum japonicum*	
Cornelian cherry	*Cornus mas*	
Cockspur hawthorn	*Crataegus crusgalli*	use thornless variety inermis
Arizona cypress	*Cupressus glabra*	'Blue Arizona'
Green ash	*Fraxinus pennyslvanica*	potentially large tree
Ginkgo	*Ginkgo biloba*	'Fastigiata', 'Princeton Sentry'
Honeylocust	*Gleditsia triacanthos*	use thornless variety/cultivar inermis 'Shademaster'
Foster's holly	*Ilex x attenuata*	'Fosteri'
Savannah holly	*Ilex x attenuata*	'Savannah'
Chinese juniper	*Juniperus chinensis*	'Torulosa' (Hollywood juniper)
Rocky mountain juniper	*Juniperus scopulorum*	'Pathfinder', 'Skyrocket', 'Wichita Blue'
Eastern redcedar	*Juniperus virginiana*	'Burkii'
Goldenraintree	*Koelreuteria paniculata*	
Japanese crape myrtle	*Lagerstroemia fauriei*	'Apalachee', 'Dynamite', 'Fantasy', 'Ludi', 'Wichita', 'Zuni'
Southern magnolia	*Magnolia grandiflora*	'Alta', 'Hasse', 'Little Gem'
Sweetbay magnolia	*Magnolia virginiana*	
Crabapple	*Malus baccata*	'Columnaris'
Crabapple	*Malus x*	'Sentinel'
American hophornbeam	*Ostrya virginiana*	
Persian parrotia	*Parrotia persica*	
Chinese photinia	*Photinia serrulata*	

Common Name	Latin Name	Cultivars and Comments
Chinese pistache	*Pistacia chinensis*	
Sawtooth oak	*Quercus acutissima*	
Scarlet oak	*Quercus coccinea*	potentially large tree
Overcup oak	*Quercus lyrata*	potentially large tree
Swamp chestnut oak	*Quercus michauxii*	potentially large tree
Chinese evergreen oak	*Quercus myrsinifolia*	
English oak	*Quercus robur*	'Fastigiata'
Japanese pagodatree	*Sophora japonica*	
Pondcypress	*Taxodium ascendens*	potentially large tree
Arborvitae	*Thuja occidentalis, T. orientalis, T. plicata*	
Littleleaf linden	*Tilia cordata*	
Lacebark elm	*Ulmus parvifolia*	
Chastetree	*Vitex agnus-castus*	
Japanese zelkova	*Zelkova serrata*	

*Confirm mature height and spread, and cold and heat tolerance, for appropriateness for your geographic site and location before planting.

Trees Unsuitable for Restrictive Paved Areas Due to Large Surface Roots

Norway maple	*Acer platanoides*
Red maple	*Acer rubrum*
Silver maple	*Acer saccharinum*
River birch	*Betula nigra*
Hackberries	*Celtis spp*
Beeches	*Fagus spp.*
Sweetgum	*Liquidambar styraciflua*
Southern magnolia	*Magnolia grandiflora*
London planetree	*Platanus x acerifolia*
American sycamore	*Platanus occidentalis*
Pin oak	*Quercus palustris*
Willow oak	*Quercus phellos*
Live oak	Quercus virginiana
Weeping willow	*Salix babylonica*
American elm	*Ulmus americana*

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Appendix C:Urban Canopy Cover Pre-Assessment Data

Residential	Address	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground % Canopy
1	5844 Prairie Ridge Dr	40	5		
2	5500 Schutta Rd	30	50		
3	1698 Hillview Rd	35	45		
4	1548 Oakwood Terrace	35	35		
5	5600 Silverthorn Pl	60	10		
6	5642 Royal Oaks Dr	30	25	50	30
7	5872 Fern Wood St	30	20		
8	5978 Royal Oaks Dr	40	55	40	40
9	5990 Scenic Place	30	20		
10	Pheasant Dr	40	40		
11	Alameda St	30	35		
12	St. Albans St N	20	40		
13	St. Albans Cir	40	25		
14	676 Pinewood Dr	30	20	30	50
15	5556 Chatsworth St.	20	35	30	35
16	Biran Trail	45	20		
17	4762 Kent St	40	20	25	30
18	David Ct	55	20		
19	Donegal dr	65	40		
20	Carol Ln	10	90		
21	Walnut Ln	30	35		
22	Lake Bayview Ct	30	35		
23	Park Overlook Dr	40	45		
24	Timber Ln	40	60		
25	Cobb Rd	40	55		
26	Harriet Ct	35	45		
27	Glen Paul Ct	35	60		
28	Island Lake Ave	30	60		
29	Dawn Ave	35	45		
30	Victoriat Ct	35	25		
31	Floral Dr W	10	70		
32	Dawn Ave	50	30		
33	Harbor Ln	25	55		
34	Countryside Dr	35	25		
35	Red Pine Rd	30	45		
36	Kevin Ln	30	55		
37	Victoria St N	25	80		
38	Monterey Dr	40	10		
39	Tangelwood Dr	25	50		
40	Crystal Ave	35	5		
41	985 Robinhood Ln	40	40	40	40
42	5400 Lake Ave	30	70		
43	5300 Lexington Ave	15	70		
44	5302 Lexington Ave	60	40		
45	5200 W Lake Beach Ct	70	20		
46	1038 Nelson Drive	30	80		
47	5000 Lexington Ave N	10	80		
48	Hanson Rd and Oakridge Ave	20	60		
49	918 Robinhood Pl	65	50		

Residential	Address	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground % Canopy
50	805 Lakeview Dr	45	65		
51	Larson Rd and Mercury Dr W	65	35		
52	600 Schifsky Rd	50	45		
53	600 Sunset Ct	20	75		
54	5082 Alamaeda St	40	55		
55	5100 St. Albans St N	35	75		
56	5200 Hodgson Rd	15	85		
57	5400 Lake Pine Dr	20	75		
58	5300 Carlson Rd	10	20		
59	720 Turtle Lake Rd	25	75		
60	800 Turtle Lake Rd	75	40		

Residental Boulevards	Address	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground % Canopy
1	5844 Prairie Ridge Dr	75	5		
2	1698 Hillview Rd	50	35		
3	1548 Oakwood Ter	50	15		
4	5600 Silverthorn Pl	50	0		
5	5642 Royal Oaks Dr	65	0	75	10
6	5872 Fern Wood St	70	20		
7	5978 Royal Oaks Dr	65	35	75	20
8	5990 Scenic Pl	80	25		
9	676 Pinewood Dr	65	35	50	40
10	5556 Chatsworth St.	50	45	55	10
11	4762 Kent St	70	45	55	45
12	David Ct	70	40		
13	Donegal dr	50	25		
14	Carol Ln	75	50		
15	Walnut Ln	60	60		
16	Lake Bayview Ct	80	5		
17	Park Overlook Dr	75	20		
18	Timber Ln	50	75		
19	Cobb Rd	55	45		
20	Harriet Ct	75	30		
21	Glen Paul Ct	60	10		
22	Island Lake Ave	65	35		
23	Dawn Ave	70	30		
24	Victoriat Ct	75	35		
25	Floral Dr W	60	60		
26	Dawn Ave	60	5		
27	Harbor Ln	80	10		
28	Countryside Dr	60	5		
29	Red Pine Rd	55	15		
30	Kevin Ln	65	50		
31	Victoria St N	80	60		
32	Monterey Dr	50	25		
33	Crystal Ave	50	0		
34	985 Robinhood Ln	50	30	50	10
35	5200 W Lake Beach Ct	70	30		
36	1038 Nelson Drive	60	50		
37	Hanson Rd and Oakridge Ave	60	30		
38	918 Robinhood Pl	50	70		
39	805 Lakeview Dr	60	0		
40	Larson Rd and Mercury Dr W	65	15		
41	600 Schifsky Rd	70	0		
42	600 Sunset Ct	65	20		
43	5082 Alamaeda St	50	75		
44	5100 St. Albans St N	50	55		
45	5400 Lake Pine Dr	60	30		
46	5300 Carlson Rd	60	40		
47	720 Turtle Lake Rd	70	20		
48	800 Turtle Lake Rd	60	20		

Commercial	Intersection	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground% Canopy
1	Hodgson Rd. & hwy 96 SW corner	45	10	60	40
2	Victoria St. & County Hwy G	90	5		
3	Gramsie Rd. & Rice St.	60	5		
4	Target Rd. & Lexington Ave.	90	5		
5	Lake Johanna Blvd.& Lexington Ave.	90	5	85	5
6	Kent St. & County Rd. E	40	40		
7	County Rd E West & HWY 49	95	3		
8	N. Owasso Blvd. & Rice St.	60	15		
9	Victoria St. & 694	95	3		
10	Tanglewood Dr. & Hodgson Rd.	80	13		
11	Lexington Ave. & County Hwy G	60	4		
12	Gramsie Rd. & Chatsworth St.	90	5		
13	Hodgson Rd. & Rice St.	50	25		
14	Lexington Ave. & County Rd. E West	85	5		
15	Lexington Ave. & Grey Fox Rd.	90	5		
16	Cardigan Rd. cul-de-sac	80	10		
17	County Rd. E West & 694	50	25		
18	Chatsworth St. & Snail Lake Blvd.	90	5		
19	Victoria St. & County Rd. E West	20	20		
20	Lexington Ave. & Cannon Ave.	50	10		

Commercial	Intersection	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground % Canopy
1	Hodgson Rd. & hwy 96 SW corner	45	10	60	40
2	Victoria St. & County Hwy G	90	5		
3	Gramsie Rd. & Rice St.	60	5		
4	Target Rd. & Lexington Ave.	90	5		
5	Lake Johanna Blvd.& Lexington Ave.	90	5	85	5
6	Kent St. & County Rd. E	40	40		
7	County Rd E West & HWY 49	95	3		
8	N. Owasso Blvd. & Rice St.	60	15		
9	Victoria St. & 694	95	3		
10	Tanglewood Dr. & Hodgson Rd.	80	13		
11	Lexington Ave. & County Hwy G	60	4		
12	Gramsie Rd. & Chatsworth St.	90	5		
13	Hodgson Rd. & Rice St.	50	25		
14	Lexington Ave. & County Rd. E West	85	5		
15	Lexington Ave. & Grey Fox Rd.	90	5		
16	Cardigan Rd. cul-de-sac	80	10		
17	County Rd. E West & 694	50	25		
18	Chatsworth St. & Snail Lake Blvd.	90	5		
19	Victoria St. & County Rd. E West	20	20		
20	Lexington Ave. & Cannon Ave.	50	10		

Parks:	Address	Aerial % Impervious	Aerial % Canopy	Ground % Impervious	Ground % Canopy
1	Shamrock Park	10	0		
2	Shamrock Park (tennis court/trees)	20	15	0	30
3	McCullough Park	0	0		
4	McCullough Park	0	0		
5	McCullough Park	15	10		
6	McCullough Park	8	50		
7	Bucher Park	0	0		
8	Bucher Park	10	15		
9	Rice Creek Fields	8	15		
10	Commons Park	80	10		
11	Commons Park	10	55		
12	Commons Park	15	60		
13	Sitzer Park (Tennis Court)	60	20	75	15
14	Sitzer Park	20	20		
15	Wilson Park	75	0		
16	Wilson Park	8	10		
17	Bobby Theison Park	10	50		
18	Bobby Theison Park	70	0		
19	Bobby Theison Park	0	10		
20	Lake Judy Park	10	80		

Summary Statistics:

Residential

	Impervious	**Canopy**
Mean	35.3 %	51 %
Median	35 %	45 %
Mode	30 %	20 %

Standard Deviation of Ground Truthed plots to Aerial Photo
Impervious 1.76
Canopy 3.54

Commercial

	Impervious	**Canopy**
Mean	69.3 %	10.9 %
Median	80 %	5 %
Mode	90 %	5 %

Standard Deviation of Ground Truthed plots to Aerial Photo
Impervious 0.00
Canopy 9.72

Parks

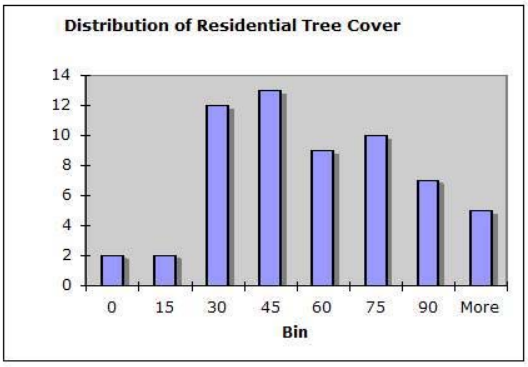
	Impervious	Canopy
Mean	21.5 %	21 %
Median	10 %	12.5 %
Mode	10 %	0 %

Standard Deviation of Ground Truthed plots to Aerial Photo
Impervious 1.77
Canopy 3.54

Boulevards

	Impervious	Canopy
Mean	62.7 %	29.9 %
Median	60 %	30 %
Mode	50 %	30 %

Standard Deviation of Ground Truthed plots to Aerial Photo
Impervious 1.20
Canopy 6.51


Distribution of Residential Tree Cover
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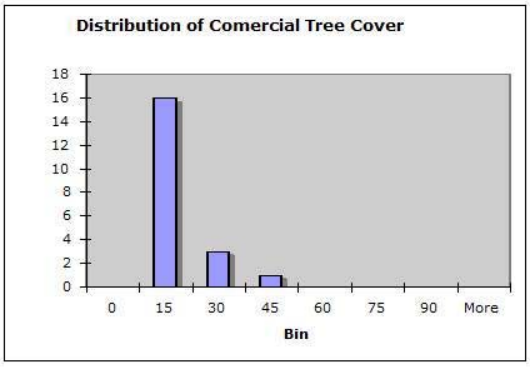
12
10
8
6
4
2
0
0
15
30
45
60
75
90
More
Bin


Distribution of Comercial Tree Cover
18
16
14
12
10
8
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4
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15
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75
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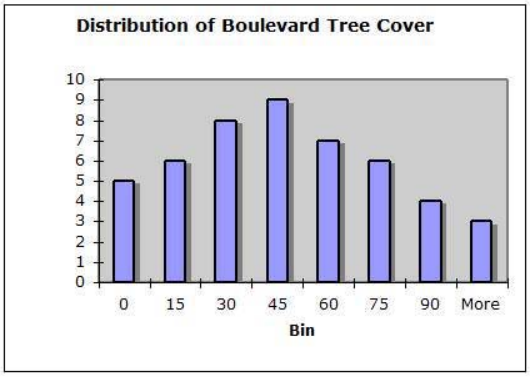
More
Bin


Distribution of Boulevard Tree Cover
10
9
8
7
6
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4
3
2
1
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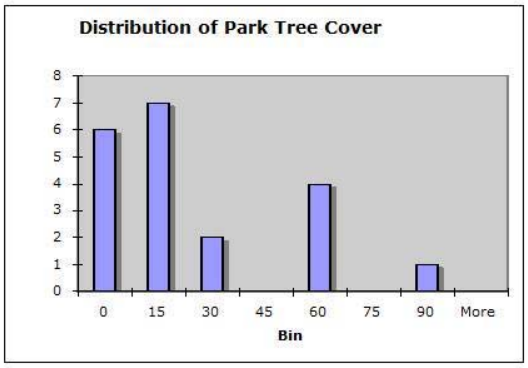
15
30
45
60
75
90
More
Bin


Distribution of Park Tree Cover
8
7
6
5
4
3
2
1
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0
15
30
45
60
75
90
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Appendix D: Genera Found in Shoreview

Latin Name	Common Name
Acer	Maple
Picea	Spruce
Fraxinus	Ash
Quercus	Oak
Pinus	Pine
Betula	Birch
Malus	Crab Apple
Populus	Poplar, Cottonwood, Aspen
Thuja	Cedar
Ulmus	Elm
Prunus	Cherry
Salis	Willow
Tilia	Linden
Gleditsia	Honey Locust
Pseudotsuga	Douglas Fir
Pyrus	Pear
Juglans	Walnut
Abies	Fir
Celtis	Hackberry